# JPL Spinoff Highlights

## The Value of Space Exploration

NASA spacecraft have paid visits to all of the planets in our Solar System except Pluto. Plans for missions in the near future include examining that distant planet, landing on an asteroid, and even returning samples of a comet and the rocks and soil of Mars. In years to come NASA will lead the way in venturing beyond our Solar System to probe the mysteries of interstellar space.

The investment America makes to undertake the innovative research necessary to create cutting-edge research for spacecraft and instruments, and deliver them to far flung destinations, provides huge returns in science, technology, educational outreach, and commercial spinoffs through an innovative program that benefits us in our everyday lives.

Understanding gained through NASA research and space exploration promotes more effective skills in a wide range of everyday technologies and aids in producing and processing many materials, including metals, semiconductors, polymers and glass. A great example is the area of semiconductors, which have contributed improved efficiency in the computer and electronic communications revolution and support today's information-driven society. We drive cars and fly airplanes that were designed using NASA computer software. We live in homes and work in office buildings that carry electricity through flat conductor cables that incorporate NASA technology.

American space research has paid off handsomely for our nation, especially considering that the total allocation for NASA is less than one penny for every dollar in the 1.5 trillion dollar Federal budget. The rewards in commercial spinoffs helping grow the American economy are many times the return on this investment.

NASA has an ongoing commitment to provide benefits to everyone. As explorers, pioneers and innovators, NASA scientists, technologists and engineers boldly expand the frontiers of air and space to inspire and serve America and benefit the quality of life on Earth. Take a look at some of the NASA breakthroughs that have become successful spinoffs over the years. They were all a result of responding to the demands of our mission, *"to do what no one has done before"*.

# JPL Spinoff Highlights

## Communications

### Space Communications

Communicating with spacecraft demands the ability to speak and listen accurately across the vast expanse of space under harsh conditions. Developing the capability to send and receive over these long distances required a long-term series of innovations leading to the development of deep space antennas, precision timing systems and data processing codes.

These leaps in technology made Earth-orbiting and planetary exploration missions possible. JPL - the Jet Propulsion Laboratory, a NASA facility in Pasadena, California - developed error-correcting codes for communicating with spacecraft by establishing Reed-Solomon error correcting codes. These codes are information added to a transmitted spacecraft computer word that allows mission controllers to determine if the word has been corrupted, and to correct it so that the original information can be obtained. This allows mission controllers to convert the weak signals from distant spacecraft into valuable scientific and engineering information.

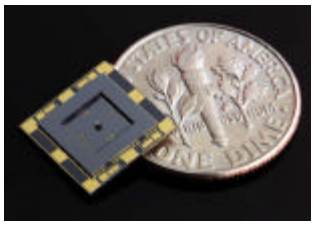
These advanced error correction codes are perfectly suited for deep space applications, but they also have very important commercial applications. Error correction codes, to lessen noise, are utilized in direct satellite TV and the multi-billion dollar communications industry, including pioneer companies such as McCaw Cellular - now part of AT&T.

### Lasers and Communications

Lasers drill, cut, melt materials and are employed during precision surgeries on the human eye. They can also be used to transmit communications signals. Many of the advanced uses of lasers were developed at JPL for optical communications over interplanetary distances.

The precise signal capabilities of these instruments make them a valuable tool in communication improvement for future NASA deep space missions. Their compact size, efficiency and durability also make laser technology attractive for future space interferometers - a new breed of telescopes on NASA drawing boards. Laser-based optical communications are a major factor fueling the rapid expansion of technology in the computer-based communication arena, and elsewhere in the commercial market.

### Micro-Gyroscope for Global Communications

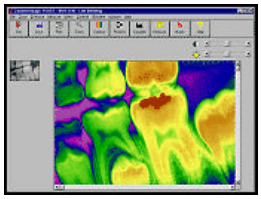


Smaller than a shirt button, and jointly developed by JPL and Hughes Space and Communications Company, this new gyroscope is lighter, cheaper, higher performing and less complex than its conventional counterparts - while ruggedly designed for continuous space operation. Hughes will use microgyros in its fleet of communications satellites. Other applications potentially include most anything that moves.

## Computers, Instruments & Electronics

### Next Generation Imaging Sensor-Active Pixel Sensor (APS)

These new imaging sensors require one-hundredth the power, and are one-tenth the size of comparable technology their predecessors, making them ideal for meeting the NASA goal of providing future missions lighter-weight and lower-powered instruments.



Smaller, faster, cheaper works well for industry, where the APS has already found uses in the automotive and medical fields. The low power needs of APS allows the physician to track the onset of osteoporosis, or perform dental radiography, using less than one-hundredth the radiation dosage to the patient. Photobit, a spinoff company from JPL, continues to work on such applications as air bag sensors, rear vision systems, digital cameras, machine vision, toys and entertainment and back up collision avoidance. Their latest development includes a new product that can be swallowed like a pill and takes images of the stomach and small bowel as it passes through them unaided. The capsule, which measures 11mm x 30mm, helps eliminate drawbacks associated with other methods of internal imaging, which can be expensive, produce limited results, or cause discomfort for patients.

### Data Compression

Data compression techniques condense the large amounts of information transmitted from remote spacecraft into smaller pieces. This increases the speed of the information returned on interplanetary missions, and contributes to the more efficient functioning of earth-based networks like the internet.

## Health and Medical

### Body Imaging

The high-tech art of Digital Signal Processing (DSP) was pioneered at the Jet Propulsion Laboratory in the mid-1960s, for use in the Apollo Lunar Landing Program. Designed to allow computer-enhancement of pictures of the moon, this technology became the basis for the Landsat Earth resources satellites, and subsequently has been incorporated into a broad range of Earthbound medical and diagnostic tools.

Physicians and engineers in the Department of Radiology at the University of Michigan Hospitals, are developed a method for combining the best features of MRI and CT scans, to increase the ability to discriminate one type of body tissue from another. These technologies stem from JPL Digital Signal Processing breakthroughs. One of their research tools is a computer program originally developed to distinguish Earth surface features in Landsat image processing. This program, called HICAP, can be used to distinguish between healthy and diseased tissue using body imaging.

### Robotic Arm for Surgery

Technology developed by Computer Motion Inc. under a Small Business Innovation Research contract, produced a robotic arm that assists surgeons in the operating room in surgical procedures. This arm takes over the job of a surgical assistant, holding and positioning the laparoscope used by the surgeon to see inside the patient through a small incision. Hundreds of minimally invasive heart valve surgeries have already been completed with robotic assistance.

Computer Motion Inc. has gone on to create robotic operating room control centers with voice control interfaces. This centralizes a surgeon's control of multiple robotic devices. Surgeons can directly maneuver these smart devices using either voice control or a hand-held touch-screen pendant. The equipment also provides the surgical team with video and voice feedback on the status of each robotic device.

The combination of human and robotic skills, made possible by these Computer Motion Inc. innovations, may some day be used to service satellites in space, monitor experiments on the Space Station, or assist in the servicing and inspection of Shuttle payloads.

### Telltale Nitric Oxide Reveals Breast Cancer

The war against breast cancer has a new weapon, thanks to an advanced sensor developed at JPL. The QWIP (Quantum Well Infrared Photodetector) camera uses extremely sensitive infrared sensors to do non-invasive mammography.

QWIP sensors were developed at JPL for astrophysics and atmospheric research. In the past, these devices had to be cryrogenically cooled, making them heavy and power hungry. JPL has advanced the state of QWIP imaging such that they are now portable and do not require subzero cooling to achieve accurate sensitivity readings.

Early versions of the sensor showed potential applications, such as locating hot spots during fires and observing volcanoes. A refined spinoff device, using QWIP camera technology, has more subtle medical applications. Studies determined that cancer cells exude nitric oxide. This causes changes in blood flow in tissue surrounding cancer that can be detected by a QWIP sensor-based system created by OmniCorder Technologies in Stony Brook, N.Y. They developed a BioScan System to screen woman for breast cancer, and received clearance to market the system in December 1999.

The BioScan System is sensitive to temperature changes of less than .015 degree Celsius (.027 degree Fahrenheit) and has a speed of more than 200 frames per second. It causes no discomfort to the patient and uses no ionizing radiation.

**Document Monitor**

Charge-coupled device technology is also helping to preserve some of America's most treasured documents, including the U.S. Constitution, Declaration of Independence and the Bill of Rights.

That effort began in 1982 when the National Archives asked JPL to develop a systematic method of assessing the condition of historic documents. JPL, in turn, asked the Perkin-Elmer Corporation, of Norwalk, Connecticut, the optical systems prime contractor for Hubble, to apply its expertise to the development of a precise photometer and then to integrate it into a complete document monitoring system. Perkin-Elmer started work in 1984 and, three years later, installed the system at the National Archives. The photometer can detect changes in contrast, shape, or other indicators of degradation with five to ten times the sensitivity of the human eye. Images are captured at precise intervals and compared to previous ones, with special attention to changes in readability due to ink flaking or fading, changes in document dimensions resulting from shrinkage, and enlargement of existing tears and holes.

The National Archives is exploring other uses for the electronic camera, including methods of measuring the effects of conversion treatments on historical documents and authentication of artwork.

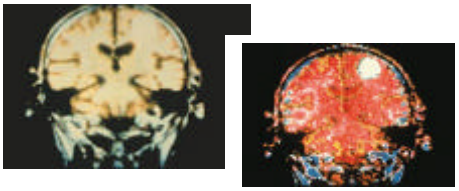
**Implantable and External Pumps for Diabetics**

Insulin-dependent diabetics have been aided by the use of space technology in the development of both external and implantable insulin delivery systems. A computerized pump can serve as an electronic pancreas to infuse insulin at a pre-programmed rate. This allows for more precise control of blood sugar levels, without which complications such as blindness and kidney disease may result. This frees the diabetic from the burden of daily insulin injections. Both patient and physician can adjust the insulin delivery rate using digital telemetry, a technique developed by NASA to communicate with spacecraft from Earth.

NASA technology also helped create the pumping mechanism, which is based on a design for the biological laboratory of the Mars Viking space probe, developed at JPL. The device delivers insulin into the abdominal cavity in short pulses, which conserves battery power. When an insulin refill is needed, about four times a year, it can be injected without surgery by a special hypodermic needle.

A similar device, but worn externally, is the MiniMed 5O4 Insulin Infusion Pump. Similarly based on NASA technology, the MiniMed SO4 can be clipped to a belt and worn continuously. About the size of a credit card and weighing just 3.8 ounces, it houses a microprocessor, long-life battery, and a syringe reservoir filled with insulin. The syringe is connected to an infusion set that consists of a thin, flexible plastic tube about 3O inches long with a needle at its end. The patient inserts the needle subcutaneously, usually in the abdomen. Insulin is infused at rates determined by the patient's need, as programmed into its microprocessor.

**Digital Imaging**



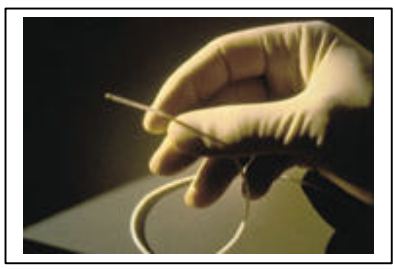
Developed in the mid-1960s to explore the surface of the Moon, Digital Imaging - a process that turns analog signals into digital signals which are, in turn, fed into a computer for enhancement - returned sharp, accurate images of the lunar surface.

This began a steady stream of advances in digital image processing, spurred by the advent of ever-more sophisticated spacecraft transmitting immense volumes of image data from distances farther and farther from Earth. In the years following, JPL pioneered use of digital processing techniques to enhance electron microscope, x-ray, and light microscope images. Among the medical applications derived from this technology are Computed Aided Tomography (CAT) scanning, diagnostic radiography, brain or cardiac angiography, sonar body imaging, surgery monitoring, and nuclear magnetic resonance.

**Infrared Ear Thermometer**

JPL expertise with infrared sensors used to measure the birth of stellar nurseries has been applied in ear (aural) thermometers. The infrared thermometer is able to provide an accurate reading in two seconds or less by painlessly placing a hand-held sensor into the ear opening. These are much more comfortable and faster than conventional mercury thermometers.

### Laser Angioplasty



Excimer laser technology uses relatively cool ultraviolet light, rather than the heat intensive light of other lasers, to vaporize plaque blockages in coronary arteries without damaging artery walls. The success rate in opening blocked coronary arteries is 85 percent, with fewer complications than in conventional balloon angioplasty. Using this spinoff technology, a company called Spectranetics continues to advance the state of excimer lasers in healthcare.

The main objective of Spectranetics' core laser technology is to reduce obstructive tissue and restore blood flow through minimally-invasive means that are safe, efficient and cost-effective - and/or to facilitate the removal of pacemaker and ICD leads.

Spectranetics' multi-purpose excimer laser system utilizes disposable fiberoptic delivery devices (catheters) to emit ultraviolet light in controlled energy pulses to ablate occlusions.

This technology is widely used to ablate arterial plaque as an alternative or adjunct to other angioplasty procedures and to remove scar tissue, which facilitates cardiac lead removal. Spectranetics continually improves its core laser technology with advanced product features.

Because of its success, the Excimer Laser Angioplasty System was honored by the US Space Foundation Space Technology Hall of Fame (http://ussf.com/hof/).

## Safety

### Radiation-Blocking Lenses

Taking a tip from nature, and a technology spinoff from NASA, Suntiger Biomedical optics (http://www.suntigers.com/) in North Hollywood, California, produced a line of sunlight-filtering glasses that protect human vision by blocking blue, violet and ultraviolet light.

Research has shown these can cause eye disorders such as cataracts and senile macular degeneration. The Suntiger PST (Polarized Selective Transmission) lenses stylishly filter out 99 percent of these potentially harmful wavelengths.

### Space Technology Helps Firefighters

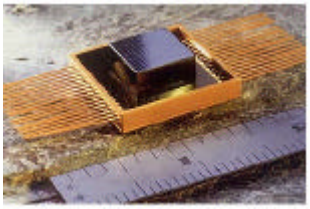
The same technology that releases a Space Shuttle orbiter from its giant fuel tank - by exploding huge fasteners - has been incorporated into cutters that firefighters use to free crash victims from smashed cars and reduces the probability of lower back injuries to rescue personnel. Explosive power cartridges are the secret of Life-Shear cutters - lightweight, portable emergency rescue cutters for situations where saving seconds means saving lives. High-Shear Technology Corp. of Torrance, Calif., teamed with JPL and the City of Torrance Fire Department to develop and field-test the Lifeshear.

This equipment weighs less than 15 pounds, takes about 30 seconds to set up, and requires no pumps or motors for operation. In 1995, the Lifeshear cutter was used at the site of the Oklahoma City Federal Building disaster. After this successful use, FEMA immediately ordered 40 of the cutters and 7,000 of the initiators/power units. FEMA has also recommended the purchase of the Lifeshear cutters by all urban search-and-rescue groups throughout the United States.

## TRANSPORTATION & POWER SOURCES

### Neural Net Chip

Ford Motor Co. signed a licensing agreement with JPL for use of neural net technology to diagnose misfiring under the hoods of Ford automobiles, among many potential applications. The vehicle applications will mean that artificial neural networks will learn how to diagnose problems, such as engine misfires and to control the engine to optimize fuel economy and emissions.

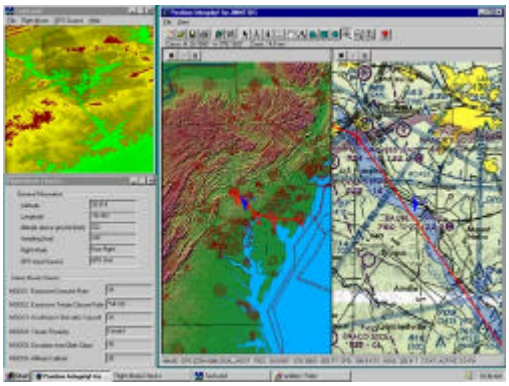


### Photovoltaic Solar Energy

When sunlight strikes certain materials, such as silicon, electrons are set in motion. These mobile electrons can be drawn off as electricity. This basic principle of photovoltaic conversion, or PV, is used to provide power to nearly all man-made satellites. NASA pioneered PV power for spacecraft and has supported U.S. Department of Energy programs to expand Earth applications. NASA's Jet Propulsion Laboratory is the group primarily responsible for developing advanced PV technology while cutting its costs.

PV power has proven a viable alternative energy source in areas where no conventional source exists, such as remote automated weather stations, sea-based navigational buoys, forest stations, and third world villages. PV arrays are routinely used at remote communications installations to operate large microwave repeaters, TV and radio repeaters, rural telephones, and small telemetry systems that monitor environmental conditions.

**Terrain Collision Avoidance System**



Synthesis of digital maps and GPS data, using NASA expertise in synthetic aperture radar, has been applied in a terrain-mapping program for small aircraft. Dubbs & Severino, a small business located in Southern California has developed terrain collision avoidance software that continuously displays an 8 minute safety zone with local terrain information in any weather. Their system runs on a battery-powered laptop in the cockpit of small aircraft for one-tenth the cost of comparable systems.

**Software for Safer Skies and Earth Monitoring**

During the 1980s The Jet Propulsion Laboratory, NASA and other research centers began to work toward developing a capability for precise positioning using Global Positioning System (GPS). This lead to a spinoff technology known as GIPSY-OASIS. GIPSY stands for GPS-Inferred Positioning System. OASIS is an acronym for Orbit Analysis and Simulation Software. This system is now in worldwide use to generate the most accurate GPS positioning solutions ever achieved.

Recent enhancements enabled scientists to precisely estimate changes in ocean height, helping led to better predictions of oncoming storms wrought by El Nino. The El Nino and La Nina events effect millions of people and billions of dollars globally.

Raytheon has developed a commercial spinoff of a real time version of this system for implementation into the FAA Wide Area Augmentation System (WAAS), which will provide all commercial airliners in U.S. airspace with accurate real-time knowledge of their position. WAAS has the potential to save billions of dollars in fuel and flight costs, while greatly enhancing aviation safety for millions of travelers.

GIPSY is also used with the Southern California Integrated GPS Network array to record millimeter-scale slips on faults and monitor the strain accumulation in Southern California's crust. Understanding of area seismic activity could lead to a better grasp of the mechanics of earthquakes and to better assessment of the damage they might do.

This NASA developed technology is made available at no cost for scientific research uses. Through licensing programs, it has moved from into the U.S. private sector, for use by companies such as Raytheon, Lockheed-Martin, TRW, Orbital Sciences, Stanford Telecommunications, Computer Sciences, Illgen Simulations and Ball Aerospace.

### Ephemerides Data

Navigating the solar system requires planetary and lunar ephemerides of the highest possible accuracy. These are tabular measurements of the assigned places of celestial bodies in space. JPL planetary orbital calculation formulas are now available both by web (http://ssd.jpl.nasa.gov/) and CD-ROM. The CD-ROM version is ideal for backyard astronomers who can't easily download huge amounts of data. Most of the world's almanacs are based on the JPL ephemeris data.


Historians and archeologists use ephemerides for the dating of key events. Other users of ephemerides include surveyors, the Department of Defense, weather forecasters, consulting firms, and satellite manufacturers.

## Environment

### Alaska Pipeline Heat Pipes and Sensors

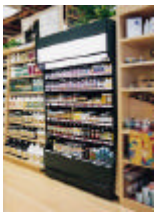
NASA heat pipe technology plays a vital role in protecting the Alaskan environment from possible pipeline oil spills. The Alaska pipeline is also looking at chemical sensors to provide monitoring ability for the pipeline to detect leaks and oil releases below the present leak detection threshold. New technologies may also help the company find leaks more quickly.

### Automated Credit Exchange

A commercial spinoff developed by Sholtz & Associates, Pasadena, California, is an electronic-bartering software. Originally the system was designed to manage the development of scientific instruments on the Cassini spacecraft on its mission to explore Saturn. Today it is helping the Southern California Air Quality Management District manage air pollution credits in a more effective way.

### Small Inner-City Business

Displaymor, a woman-owned small-business in South Central Los Angeles, faced new Food and Drug Administration requirements for lower operating temperatures of their company's refrigeration showcase products. She needed to lower her refrigerator temperature two degrees. By working with JPL engineers, who were experienced in the thermal requirements of spacecraft, they were able to redesign Displaymor's refrigeration units with space technology developed insulation to meet the new requirements from the FDA.



# Education

## IMAX Films

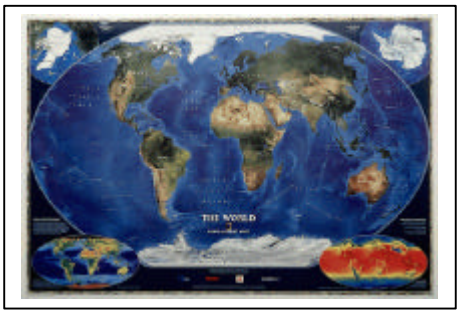
IMAX big screen cameras have been carried on numerous shuttle missions, and scores of astronauts have been trained to operate them. NASA generated computer-enhanced images of the Earth have been used to simulate fly-bys of such areas as the San Andreas fault in California. IMAX films about the space program, have been seen by millions of people around the world. A current project for IMAX is a 3D Mars movie on future robotic outposts on the Red Planet.

## Ecosphere Miniature World

Models of a miniature world in an enclosed glass globe helps students understand environmental systems. The first EcoSphere globe was modeled on an experiment by JPL scientists studying self-contained communities for space explorers to live in during long-term flights.

## National Geographic Global Satellite Map

On its hundredth anniversary the National Geographic Society made a special gift to the nation. It established an Education Foundation and endowed it with an outright gift of 20 million dollars. The earnings of the endowment were forever dedicated to improving the geographic literacy of American students by providing a permanent and expanding source of financial support for exemplary geography education programs. Their mission is to revitalize the teaching and learning of geography in the nation's K-12 classrooms.



As one of the world's largest non-profit scientific and educational entities, this Foundation worked with the JPL Cartographic Division to update a satellite imaged map. They then marked the new millennium with a gift to America's children. Each of the nation's more than 100,000 public and private schools received a 4-by-6 foot laminated, updated map of the world. One side shows the political world. The other side is a digital picture of the physical world based on images collected by with NASA satellite technology.

==========